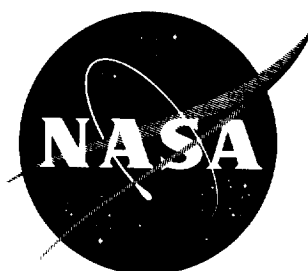


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TECHNICAL NOTE

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STAR CATALOGS ON PUNCHED CARDS AND MAGNETIC TAPE

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SUMMARY

In connection with the calibration of the Minitrack satellite tracking stations, the Goddard Space Flight Center has had the contents of a number of star catalogs put on punched cards and magnetic tape. This report discusses the plate data reduction procedures, briefly describes the information on the punched cards and magnetic tape, and calls attention to other applications of the card and tape star catalogs. The Goddard Space Flight Center has offered to prepare duplicate catalogs for qualified organizations.

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INTRODUCTION

In connection with the calibration of the Minitrack satellite tracking stations, the Goddard Space Flight Center of the National Aeronautics and Space Administration has had the contents of a number of star catalogs put on punched cards and magnetic tape. Since these cards and tapes may be useful to other organizations using star position data, Goddard is prepared to make duplicates upon request from qualified organizations.

The Minitrack stations are radio interferometers which must be calibrated in order to determine the angular position of satellites accurately. The only sufficiently accurate and complete technique for calibration requires an airplane to fly through the station antenna beam carrying a flashing lamp at the center of an antenna radiating on the satellite tracking frequency. The flashing light is photographed against a star background by means of a sidereally driven astrographic camera (40-inch focal length) located at the center of the interferometer system. The photographs are made on 8 x 10 inch glass spectroscopic plates and show a trail of flashing light images superimposed on the background star field (see Figure 1). The data from the plates yield an angular position for each light flash that is accurate to better than two seconds of arc. The necessary calibration constants for the system are obtained by correlating these known positions with the interferometer recordings.

PLATE DATA REDUCTION PROCEDURE

The plate data reduction procedure, as recommended by Dr. Paul Herget of the University of Cincinnati Observatory, requires the identification and measurement of about 40 stars on each plate. Approximately 600 plates are now reduced each year to keep the

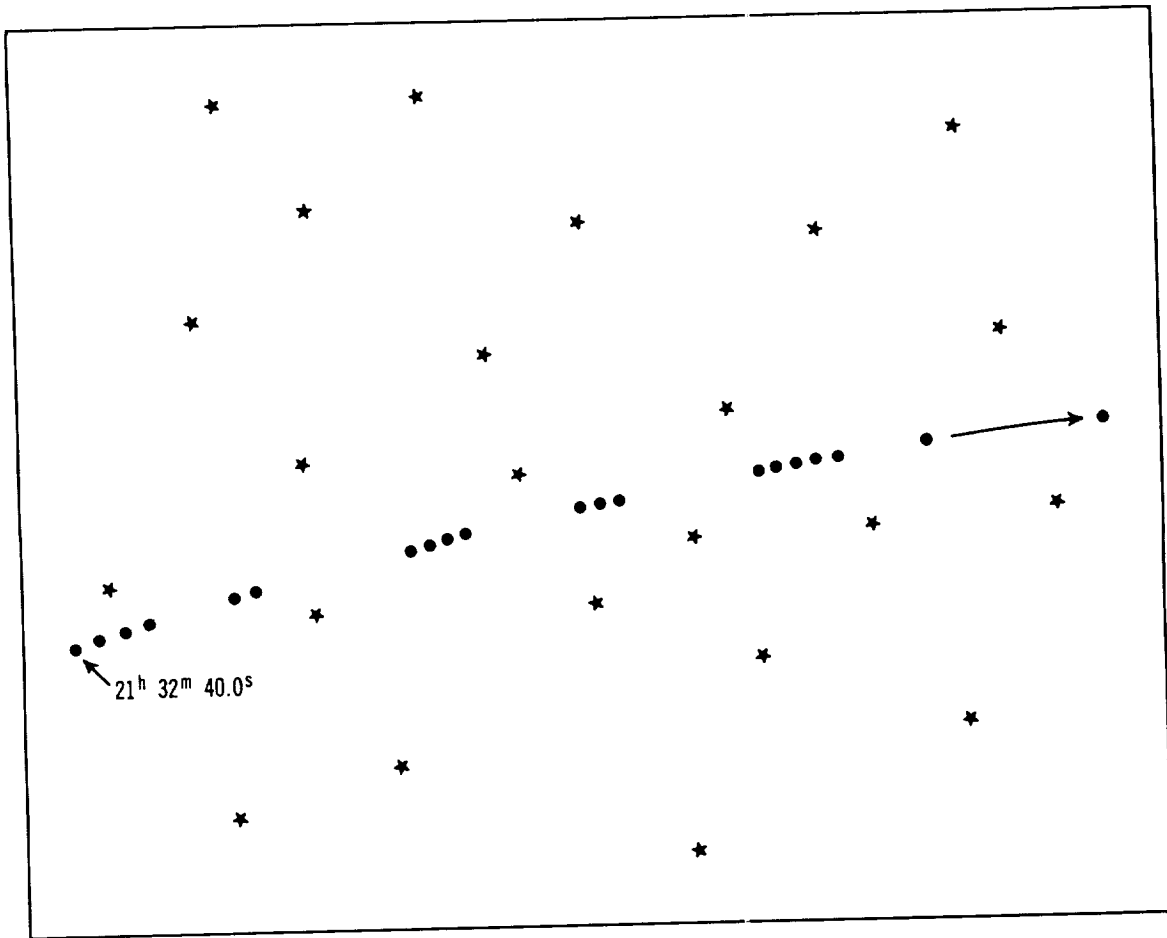


Figure 1 - Calibration plate showing trail of flashing light images against star background

network of Minitrack stations calibrated. Since May, 1957 these plates have been shipped to the Physical Science Laboratory of New Mexico State University where the plate data reductions are performed and the results mailed back to the Goddard Space Flight Center.

With a large number of plates to reduce it is essential to use efficient data reduction procedures. An improvement over the early procedures was achieved when a device which automatically reads out the x,y coordinates and punches these into cards was added to the plate measuring engine.

At Dr. Herget's suggestion, an improvement over conventional star identification procedures was achieved by reproducing the B.D. and C.D. star charts to the same scale as the calibration plates. All the star images are lined up simultaneously by superimposing the photographic plate on the proper star chart so that a few bright star images on the plate line up with the corresponding stars on the chart. This reduces the task of determining the B.D. or C.D. numbers of the 40 stars on the plate to the much simpler task of

determining these numbers for the corresponding stars on the chart. Once the B.D. or C.D. numbers are determined, the right ascension and declination for each star may be looked up in a modern catalog and punched onto a card for entry into the computer.

With the increasing availability of large memory digital computers, another labor saving technique becomes feasible. It is anticipated that all the star positions (right ascensions and declinations) given in the star catalogs used for Minitrack plate reductions will be entered into the memory of a digital computer. A preliminary plate reduction based on only six stars will then be performed in the usual manner. The resulting plate coefficients will be used to derive a right ascension and declination for each of the remaining 34 stars using the x, y coordinates measured with the plate measuring engine. The computer will be programmed to scan its memory for 34 right ascensions and declinations from the catalogs which match the derived right ascensions and declinations within the accuracy of the preliminary plate reduction. When these are found, the preliminary coordinates will be discarded and replaced by the 34 pairs of coordinates just selected from the computer's memory. The complete plate reduction can then be performed. With this technique, the number of star positions per plate which must be looked up and punched onto cards is reduced from 40 to 6.

STAR CATALOGS ON PUNCHED CARDS

With this application in mind, the Goddard Space Flight Center funded the U. S. Naval Observatory and the Yale University Observatory on a joint project to punch onto IBM cards the AGK₂, the Yale Zone, and the Cape Photographic Star Catalogs. These two organizations were obviously well aware of the intricacies inherent in measuring and cataloging star positions and were counted on to provide the most generally useful compilation of star data on the cards. Furthermore, the Naval Observatory had already punched some of the Yale Zone Catalogs for stars in the zodiacal belt and were interested in continuing this work.

The complete Punched Card Star Catalog contains approximately 300,000 cards with one star per card. Star positions and associated data are given for all stars in the original catalogs for declinations from +90 to -64 degrees and magnitudes from the fourth or fifth down to the tenth or eleventh. The list of catalogs from which the star data were taken is given in Table 1. The Yale Zone Catalogs were used whenever possible because they include proper motion. The AGK₂ Catalogs were used to the far north and the Cape Photographic Catalogs were used to the far south. The format of the data on each card is given in Table 2. This includes essentially all the data given in the catalogs for each star. However, the precession terms I, II, and III for right ascension and declination were not punched for the AGK₂ or Cape Photographic Catalogs because it was felt that any prospective user of the Punched

Table 1

Star Catalogs on Punched Cards and Magnetic Tape

Naval Observatory Number	Catalog Number	Declination (degrees)
01	AGK2 1	+70 to +90
02	AGK2 2	+60 to +70
03	Yale 27	+55 to +60
04	Yale 26II	+50 to +55
05	AGK2 5	+45 to +50
06	AGK2 6	+40 to +45
07	AGK2 7	+35 to +40
08	AGK2 8	+30 to +35
09	Yale 24	+25 to +30
10	Yale 25	+20 to +25
11	Yale 18	+15 to +20
12	Yale 19	+10 to +15
13	Yale 22II	+ 9 to +10
14	Yale 22I	+ 5 to + 9
15	Yale 20	+ 1 to + 5
16	Yale 21	+ 1 to - 2
17	Yale 17	- 2 to - 6
18	Yale 16	- 6 to -10
19	Yale 11	-10 to -14
20	Yale 12I	-14 to -18
21	Yale 12II	-18 to -20
22	Yale 13I	-20 to -22
23	Yale 14	-22 to -27
24	Yale 13II	-27 to -30
25	Cape	-30 to -35
26	Cape	-35 to -40
*27	Cape	-40 to -52
28	Cape	-52 to -56
29	Cape	-56 to -60
30	Cape	-60 to -64

*Updated to the equinox 1950.0 to match the other catalogs.

Table 2
Format on IBM Cards for Star Data

IBM CARD COLUMN NO.	DESCRIPTION
1	EPOCH
5	CATALOGUE STAR NO.
10	VIS. MAG.
14	PHOTOG. MAG.
18	SPECT. TYPE
21	COLOR INDEX
24	RIGHT ASCENSION 1950.0
32	
33	
38	I PREC. IN R.A.
39	II 1/2 SECULAR VAR. IN R.A.
43	III IN R.A.
46	PROP. MOTION IN R.A.
50	DECLINATION 1950.0
57	
58	I PREC. IN DECL.
62	II 1/2 SECULAR VAR. IN DECL.
63	III IN DECL.
66	PROP. MOTION IN DECL.
68	
72	B.D., C.D., or C.P.D. NO.
78	
80	VOL. NO.

Card Star Catalog would have access to a computer and would prefer to compute these values from the spherical trigonometric formulas.

STAR CATALOGS ON MAGNETIC TAPE

At the Goddard Space Flight Center, the 300,000 cards have been transcribed onto 16 reels of magnetic tape in binary coded decimal form. The 80 columns plus 12 signs on each punched card are recorded as a group of 92 characters with a 3/4-inch record gap between each group. The essential data for the Minitrack plate reduction and star identification program will be abstracted from the 16-reel master catalog and put onto either 2 or 4 reels of magnetic tape, whichever turns out to be most efficient.

OTHER APPLICATIONS FOR THE STAR CATALOGS

It is anticipated that there will be applications for the card or tape catalog other than the one described here. One such application would be in the reduction of data obtained from ballistic cameras and other precision cameras used for tracking missiles, aircraft, and satellites. Another application exists in the field of mapping where precise position determinations are made from many star observations. A further anticipated application of the Punched Card Star Catalog is as an aid in the measurement and control of satellite orientation from satellite borne star tracker data.

CONCLUDING REMARKS

Goddard Space Flight Center recognizes its responsibility to share the Punched Card Star Catalog with the rest of the scientific community and is prepared to provide duplicates for qualified organizations, the only stipulation being that the requestor supply the necessary blank cards or tape. More detailed information concerning the card or tape catalogs may be obtained by writing to:

Technical Information Division
Goddard Space Flight Center
National Aeronautics and Space Administration
Greenbelt, Maryland

